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Mixed Waste Focus Area Technology Development Transition Guidance

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SUMMARY

Characterizing, handling, treating, and disposing of the mixed low-level and mixed transuranic waste generated at many US Department of Energy and commercial sites is a costly, time consuming, and sometimes hazardous process. New and better technologies are needed to remove and dispose of the growing volume of mixed waste.

To expedite the implementation of new technologies, the Department of Energy's Environmental Management division created the Mixed Waste Focus Area (MWFA), which uses a systems engineering approach and a stage transition system for tracking and controlling technology development projects and placing the technology in the hands of the end user.

This document outlines the Mixed Waste Focus Area (MWFA) guidance for the development and end user/commercial partner transition of technologies (including methods or devices) for the treatment, storage, and disposal of mixed wastes in accordance with applicable US Department of Energy (DOE) Orders and regulatory requirements including the Occupational Safety and Health Act (OSHA). This guidance will be used to evaluate, track, and transition DOE-sponsored technology development activities from concept through implementation.

The transition guidance is based on the work done by Cooper, Livesy, and Paladino, and uses a series of gates, or stages, with specified criteria at each stage that must be met before the technology can advance to the next stage of development. The stages are:

Stage 1: Basic Research
Stage 2: Applied Research
Stage 3: Exploratory Development
Stage 4: Advanced Development
Stage 5: Engineering Development
Stage 6: Implementation.

As each stage is completed, MWFA compares the technology development progress to the criteria established for success and either advances, modifies, or terminates the project.

This document describes the MWFA method for guiding technology development projects through the stages of technical maturity to eventual transition to the technology's end user. This development guidance document is designed to be a MWFA management tool and will be used primarily to write Development Plans (DPs) in which the technical strategy, tasks, and multiyear progress for technology development projects are presented.

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ACRONYMS

DP	Development Plan
ES&H	Environment, Safety, and Health
MWFA	Mixed Waste Focus Area
OSHA	Occupational Safety and Health Act
PI	Principal Investigator
PMP	Program Management Plan
TDRD	Technical Development Requirements Document
TDRD	Technology Development Requirements Document
TPR	Technology Performance Report
TTP	Technical Task Plan
WTM	Waste Type Manager
WTT	Waste Type Team

MIXED WASTE FOCUS AREA TECHNOLOGY DEVELOPMENT TRANSITION GUIDANCE

INTRODUCTION

Background

This document outlines the Mixed Waste Focus Area (MWFA) guidance for the development and end user/commercial partner transition of technologies (including methods or devices) for the treatment, storage, and disposal of mixed wastes in accordance with applicable US Department of Energy (DOE) Orders and regulatory requirements including the Occupational Safety and Health Act (OSHA). This guidance will be used to evaluate, track, and transition DOE-sponsored technology development activities from concept through implementation.

The goal of the MWFA is to have a technically sound, performance-based program that results in technologies that meet the needs and requirements of the end users, regulators, tribal governments, and other stakeholders such that the technologies can be implemented effectively, efficiently, and safely. The MWFA will develop and demonstrate technologies for characterizing, handling, treating and storing mixed waste within the DOE complex. Treatment refers to all post-waste-generation activities including sampling and analysis, characterization, storage, processing, packaging, transportation, and disposal. End users are considered to be primarily EM-30, -40, and -60 (Deputy Assistant Secretary for Waste Management, Environmental Restoration, and Facility Transition, respectively). Note: See the Glossary at the end of this document for definitions of terms.

A key component of the MWFA Program Management Plan (PMP) is to ensure that technologies supported by the focus area will meet the procurement strategy of EM-30 and 40. That is, how will EM-30/40 obtain the technology: directly from a national laboratory, directly from a vendor, or indirectly through a privatization contract. This will directly affect the end user and commercial partner requirements, and participation in the technology development. As technologies obtained through privatization contracts mature, requirements and cost sharing will shift from the end user to the commercial partner who anticipates selling the technology back to the end user. In contrast, those technologies that will be obtained directly from a national laboratory will require increased cost sharing and buy-in from the end user throughout the development process. How the technology is obtained will define the rigor and emphasis placed by the MWFA on defining commercial markets and obtaining commercial partners.

This MWFA Technology Development Transition Guidance is based on the Technology Investment Decision Model[1], also known as the "Gates Model." The Gates Model is, in turn, based on Cooper[2] and Livesey[3]. The model has been in existence for more than three years and has been reviewed and discussed by personnel across the DOE complex at all organizational levels. During this time, the Gates Model was updated and refined several times.

The MWFA used the basic framework of the Gates Model and developed transition criteria as specific as possible to the application needs of the MWFA. The goal is to develop clear and concise criteria, requirements, and definitions to provide a common understanding of expectations for each life cycle stage of technology development.

For each technology deficiency identified for development, a Technology Development Requirements Document (TDRD) will be prepared in accordance with the MWFA PMP to define end user requirements. The TDRD is used by Principal Investigators (PIs) to prepare and execute test plans. TDRDs will be used by the PI and all involved parties so that all clearly understand the expectations for the development work and the requirements that must be met before transitioning the technology to the end user. In short, the TDRD outlines the specific requirements the technology development must meet to be successful.

A specific technology may require the involvement of only one or two organizations, or it may involve many different organizations. Integration into an end user's or private sector participant's facility may be simple or complex. To maintain control of complex projects, a Development Plan (DP) will be necessary to allocate technical tasks and to schedule major milestones in a multi-year technology development effort. Even for less complex projects, a DP will be prepared to schedule major milestones, including transition stages as described in this document.

The DP is prepared based on the TDRD and supporting studies and analyses. The DP describes the integrated life-cycle planning for a specific technology development and provides a mechanism for the MWFA to manage a portfolio of technology options. The DP contains descriptions of development activities, performance objectives, schedules, transition, success criteria, and life-cycle cost. This provides integration of the activities of multiple contributors over several funding cycles.

This Transition Guidance document provides the basic criteria with which to prepare the DP and the framework with which to evaluate progress. The logic flow outlining the MWFA systems engineering approach is shown in Figure 1.

The MWFA Waste Type Managers (WTMs) have overall responsibility for each project; technical aspects are coordinated by a WTM with support from of the Waste Type Team (WTT).

Technology development work is considered complete when the requirements in the TDRD are met and

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[1] J. Paladino and P. Longsworth, A Decision Model for Technology Development in the Department of Energy's Environmental Cleanup Program.

[2] Cooper, R., *Winning at New Products*, Second Edition, Reading, MA, Addison Wesley Publishing Company, 1993.

[3] Livesey, C. Heald, M. L. Rorke, and D. Lux, "From Experience - Technical Development and the Innovation Process," *Journal of Innovation Management*, 6, 1989, pp. 268-281.

a Technology Performance Report (TPR) is prepared and distributed. If it becomes clear that a technolog y approach cannot meet the TDRD requirements, a decision must be made to discontinue the project.

Technology Development Stages

Technology development progresses through various stages from theoretical concepts through a variety of working models to prototypes of various scales, and, hopefully, to commercial application. At each stage, a critical evaluation process eliminates impractical concepts, and o nly the best, most reliable and effective solutions are implemented. The following summarizes the stages of development as implemented by the MWFA. It i s important to note that Stage 1: Basic Research, is not typically fun ded by the MWFA and as such is not discussed in detail here.

- **Stage 1: Basic Research:** When used in the context of the MWFA development stages, refers to the technology development stage during which fundamental research is undertaken to build core scientific or engineering knowledge; no specific need, end-user, or application of thi s knowledge is necessarily identified at this stage. Basic research is not typically funded by the MWFA.

- **Stage 2: Applied Research.** Once a scientific principle or technique is recognized as having a practical application or a potential advantage to satisfy a known customer or market need , further development is referred to as applied research. The function of applied research is to determine the technical feasibility of applying the concept to a particular application. Th e results of applied research form a basis of estimating whether the advantage merits continued investment of resources. This is typically the earliest stage of research funded by the MWFA because it is the earliest stage of research funded by the MWFA because it is the earliest point at which connection may be made to the needs of EM-30, -40, or -60 end-users.

- **Stage 3: Exploratory Development.** This stage begins with a concept that has no identified insurmountable problems in basic principles, materials, or energy requirements. Exploratory development includes scoping studies designed to provide information to support the design of a system to demonstrate functionality and ability of the system to produce the desired result . Examples of the kind of parameters to be obtained during exploratory development includ e corrosion rates, reaction kinetics and rates, residence time, throughput as a function of size , pressure, temperature, product quality, heat transfer coefficients, etc. Data will be evaluate d with respect to stakeholder, regulatory, and safety concerns. These tests are usually fairl y simple, and to the extent possible, isolate particular phenomena from other effects, and support the conceptual design that can be used in the next stage. Preliminary ideas as to how th e technology will fit into an integrated system are developed.

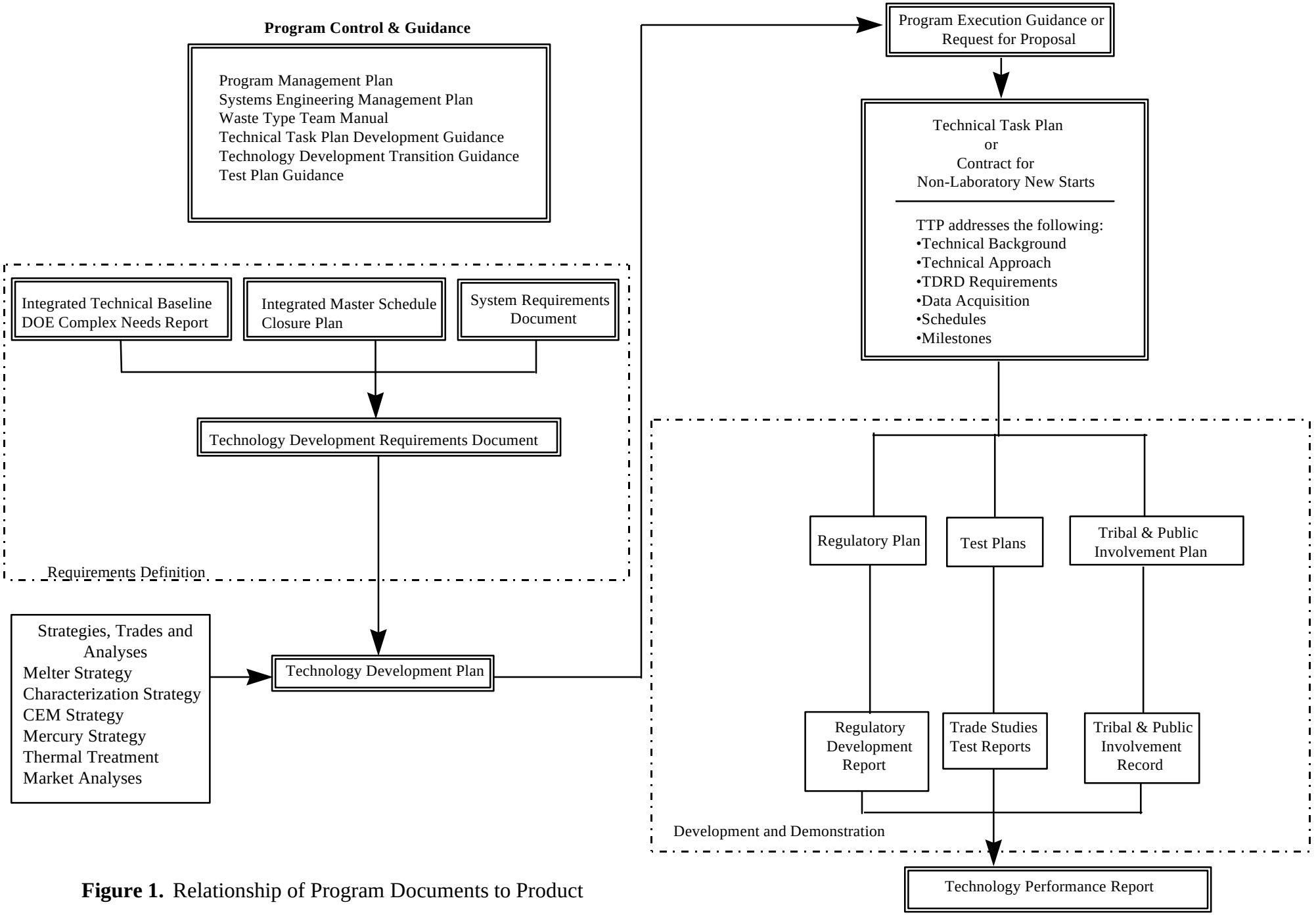


Figure 1. Relationship of Program Documents to Product

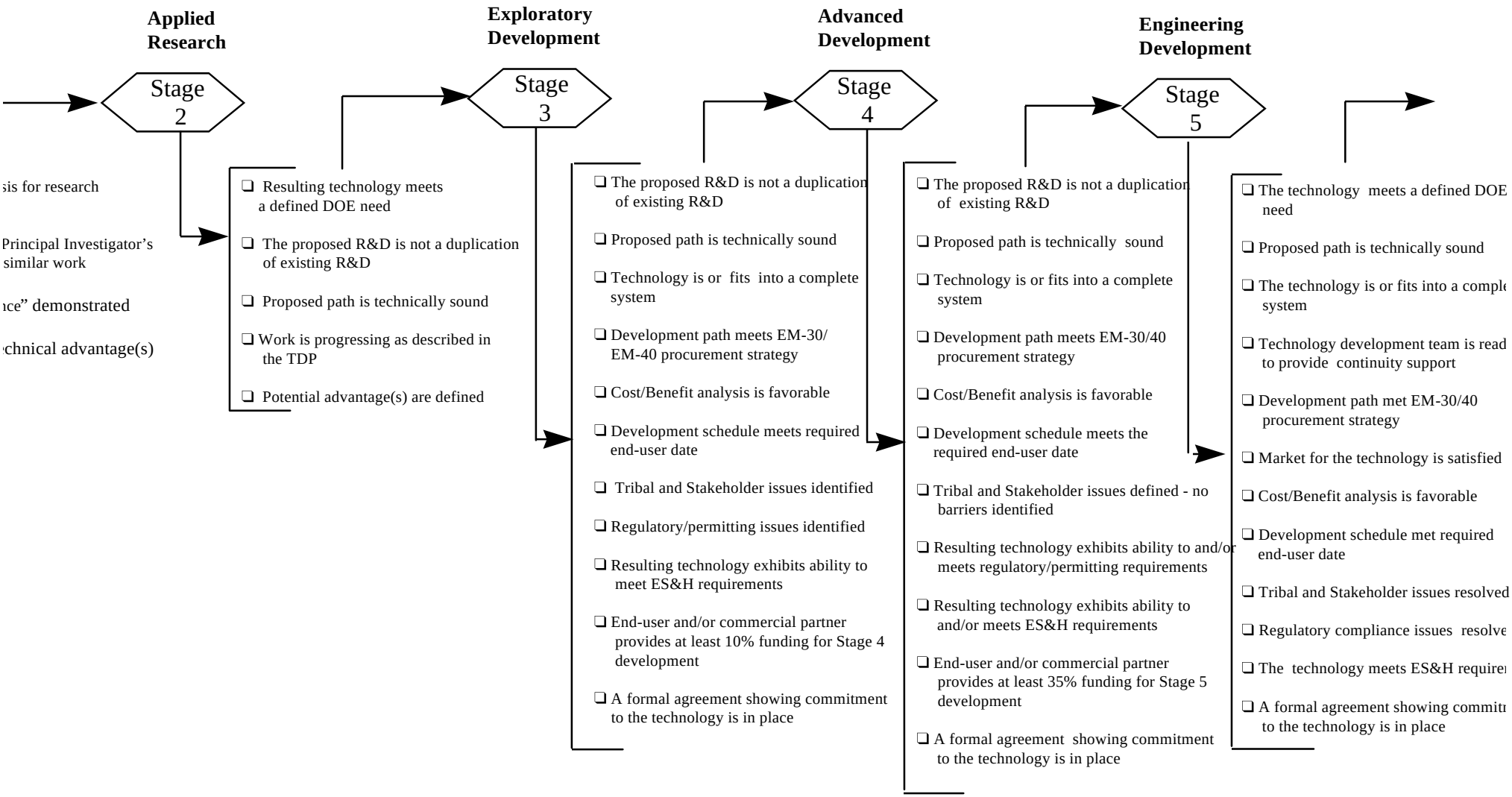
- **Stage 4: Advanced Development.** At this level, the concept is transformed into a working system. Critical steps required to make the process complete have been identified, and a bench-scale system is typically built. The term "bench-scale" was coined because at this level, the system will fit on a benchtop. This size is not a prerequisite; systems at this scale may be larger. This scale implies that the researchers believe that enough knowledge is available to begin to integrate components into an operable system. Additional applied research and scoping studies may be identified and still ongoing. Insurmountable problems may still emerge, but the focus of the work is to refine process integration and gain knowledge on component interactions. Enough data should be gained to begin to establish process efficiency and mass and energy balances, which can be used to develop cost estimates of full-scale implementation. Data will also be developed to answer stakeholder, regulatory, and safety issues. Development in this stage is directed toward specific end-user needs; therefore, joint funding by the site-specific end-user and/or a commercial partner will be sought to leverage MWFA funding.

  If bench-scale testing suggests that the technology will be technically successful, cost effective, and can satisfy stakeholder, regulatory, and safety concerns, development can proceed to Stage 5, the Engineering Development Stage. The decision to proceed involves significant collaboration with the potential end-user. Answers to several questions drive the decision such as: Is the need, as addressed by the technology, still current? Will the estimated development time meet the end-user's deadline? Are the expected costs of continued development warranted by the need? At this stage, it is expected that further development costs will be shared by the end-user.

- **Stage 5: Engineering Development.** During this stage, the process is developed to demonstrate marketability and full system functionality. When funding is committed, the MWFA Waste Type Team will identify the data requirements to support implementation (Stage 6). The Engineering Development Stage system is designed and built to whatever scale is necessary to provide that data. The system at this stage of development is typically referred to as pilot-scale or engineering-scale. The test plan for this stage will be drafted before final design and construction to ensure that the system will support collection of the required data. All data required for full-scale implementation and to apply for regulatory permits must be gathered in this stage. All stakeholder issues will be resolved. If certain data cannot be obtained due to lack of resources, scalability, or time, the test plan must propose a means of estimating or otherwise obtaining that information.

- **Stage 6: Implementation.** Technology implementation involves the design, fabrication, installation, and startup of full-scale technology in a system that will be used by the customer. Technology can be implemented directly by the customer or through a commercial vendor. All questions and issues will have been addressed to the customer's satisfaction. All necessary permits will be obtained by the customer. During startup, minor technical problems may be encountered that must be solved, but there should be no actual development during this stage. Therefore, there will be no MWFA funding during implementation. All work is conducted by the customer, vendor, and/or operations personnel under mutually acceptable terms.

MIXED WASTE FOCUS AREA TECHNOLOGY DEVELOPMENT TRANSITION CRITERIA



Example of Technology Development Stages

To illustrate the process of developing a technology, the following example describes the stages of developing a process to decaffeinate coffee.

Stage 1: Basic Research

Scientists study the ability to selectively extract complex organic molecules using different solvents. The organic molecules dissolve in the solvent without being destroyed or chemically altered. One of many solvents tested, methylene chloride, selectively dissolves caffeine. The caffeine can then be extracted from the solvent and the solvent can be reused.

Stage 2: Applied Research

An entrepreneur realizes that this could be used to decaffeinate coffee. To be successful, it must be demonstrated that (a) removal of the caffeine does not noticeably affect coffee's taste of quality, and (b) methylene chloride, a known carcinogen, must be removed without destroying the taste of quality of the coffee. Laboratory tests with coffee beans show that this is possible. Several cups of reasonably good coffee are made and tested.

Stage 3: Exploratory Development

The process works in theory and practice. Additional testing is needed to determine design parameters for a working system. The following parameters are required:

- Optimum temperature
- Optimum ratio of solvent volume to coffee bean volume
- Time and temperature to remove residual traces of solvent
- Corrosion rates of the solvent
- Process to remove caffeine from the solvent
- Safety and legal implications.

Stage 4: Advanced Development

In this stage, it is time to choose a combination of hardware, monitoring, and control systems required for an operable system. A system must be selected that works and can be built at a cost low enough to be profitable, and the coffee's quality must be high enough to attract buyers and users.

A bench-scale system is designed and built to treat 10 pounds of coffee beans per day. All steps of the process are present, but the process is not continuous and can be operated only under the control of an engineer. Operation of the system is demonstrated. Cost estimates are made showing that the system could be designed and built to be competitive in the market.

Stage 5: Engineering Development

The Hillgers Coffee Company, convinced of the system's profitability, plans to build a pilot-scale plant that will process 500 pounds of coffee beans per day. Selected test markets will sell the coffee product to determine consumer acceptance. The plant size is selected as the minimum size needed for planning the design of a 100 ton-per-day plant, yet large enough to produce the required amount of coffee to test the market.

Stage 6: Implementation

Hillgers Coffee Company builds a 100,00 square foot plant that processes 100 tons of coffee beans per day, and markets the decaffeinated coffee beans to coffee roasters. The extracted caffeine is sold to the pharmaceutical industry.

Documentation and Reporting Requirements

The information and supporting documentation required for each development stage are described in the MWFA PMP, in the appropriate sections of this document, and will be detailed in the DP as needed.

A graded approach, as agreed to by the MWFA WTM and the PI, will be used to establish the documentation rigor for each project depending on the complexity and maturity of the technology. The documentation developed during each stage is the responsibility of the MWFA and/or the PI as described in the PMP and summarized in Table 1.

As appropriate, the MWFA will hold technology reviews. Stage reviews will be scheduled as defined in the life cycle plan detailed in the DP. The MWFA will be responsible to conduct these stage reviews to evaluate the project against the TDRD and the transition guidance "go/no-go" criteria. The project review cycle and associated key products and documents are shown in Figure 3. As shown in the figure, the TDRD provides the requirements that drive the development activities for each stage. At the completion of each stage or as specified in the DP, a stage review will be conducted to determine if the technology is progressing as planned and is meeting the requirements of the TDRD. The primary emphasis of this review will be to determine if the technology is ready to transition to the next stage or if more data are required before transitioning, or if the MWFA should discontinue support for the technology. In addition, during the stage review, the TDRD is also reviewed to determine if it needs to be updated or revised.

The stages, as applied in the MWFA and described in the sections that follow, represent the maturity of the developing technology and provide the MWFA with a gauge to measure progress. At the completion of each stage, a specific set of criteria must be met before a development activity can proceed (transition) to the next stage. The MWFA will review and assess each project against the TDRD and recommend either that the project be terminated, transitioned, or rescoped before progressing to the next stage. These reviews will be held in accordance with, and as outlined in, the DP.

STAGE 1: BASIC RESEARCH (Pre-MWFA Funding)

Basic Research is the technology development stage during which fundamental research is undertaken to build core scientific or engineering knowledge; no specific need, end-user, or application of this knowledge is necessary.

The MWFA does not typically pursue basic research. Basic research is funded through other programs. It is assumed that the criteria for transition to Stage 2 have been met when the MWFA selects the technology for development.

The MWFA will determine, on a case-by-case basis, the documentation it considers adequate for acceptance as a Stage 2 technology development effort.

Go/No-Go Criteria for Stage 2 Acceptance

Before the technology is accepted for Stage 2 development, the following "go/no-go" decision criteria must be met.

- Scientific basis for research established
- Evidence of Principal Investigator's knowledge of similar and duplicative work
- "Good science" demonstrated (data generated during this stage is sufficient to establish potential application to DOE need)
- Potential technical advantage(s) over baseline and alternative technologies are defined.

Table 1. MWFA technology development guidance documentation responsibility matrix.

MWFA TECHNOLOGY DEVELOPMENT GUIDANCE DOCUMENT RESPONSIBILITY MATRIX

Document	Stage	MWFA	PI	EM 30/40	Commercial Partner
Development Plan	2	P	R/C		
	3	P	R/C	R	R
	4	P	R/C	C	R
	5	P	R/C	C	R
Technology Development Requirement Document	2	P	R	P	P
	3	P	R	P	P
	4	P	R	P	P
	5	P	R	P	P
Technical Task Plan	2	R/C	P		
	3	R/C	P		
	4	R/C	P		
	5	R/C	P		
Test Plan	2	R/C	P		
	3	R/C	P	R	R
	4	R/C	P	C	R
	5	R/C	P	C	R
Test Results	2	R/C	P	I	I
	3	R/C	P	I	I
	4	R/C	P	I	I
	5	R/C	P	I	I
Technology Performance Report	At Completion	P	R	R/C	R

P - Prepare
R - Review
C - Concur/Approve
I - Information

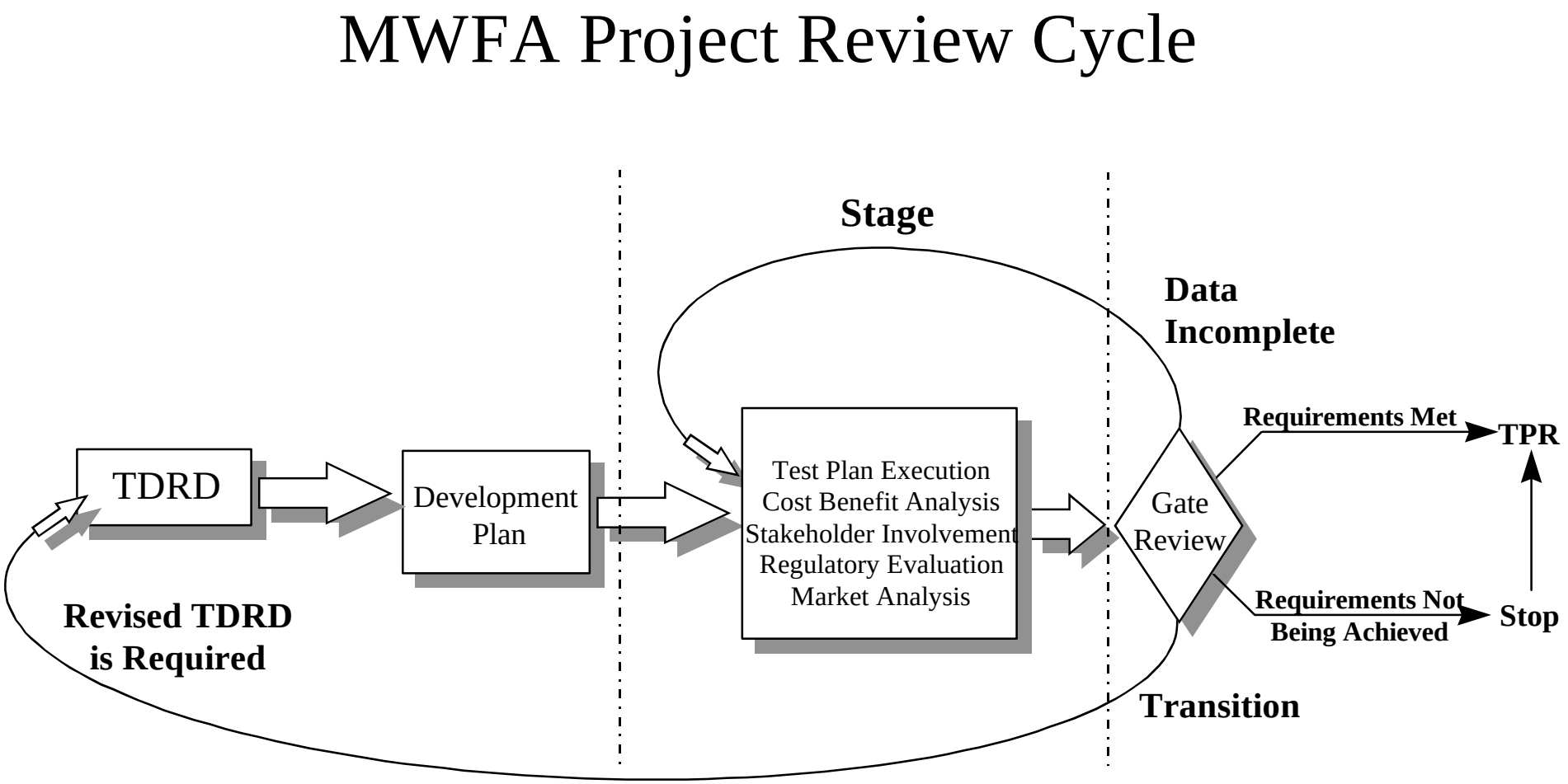


Figure 3. MWFA project review cycle.

STAGE 2: APPLIED RESEARCH

Applied Research is a continuation of basic research, with the distinction that knowledge gained from the basic research stage is applied to problems related to potential end-user needs, and practical application of this knowledge is identified and agreed to by the MWFA Waste Type Teams.

Stage 2 Information and Documentation Requirements

In the applied research stage of development, the specific information and documentation requirements necessary for the MWFA to approve work and perform a comprehensive assessment of the technology ar e described in this section. See Table 1 for documentation responsibilities and Figure 2 for transition criteria.

Before beginning work in Stage 2, the following documents are needed:

- Technology Development Requirements Document (TDRD)
- Development Plan (DP)
- Test Plan
- Market Analysis Report (as directed by the MWFA).

At the end of Stage 2, the PI will report results as required in the Technical Task Plan (TTP) and will also be available for formal and informal program reviews as requested by the MWFA.

Go/No-Go Criteria for Transition to Stage 3

Before transitioning the technology development to the next stage, the following "go/no-go" decisio n criteria must be met:

- Resulting technology meets an evolving or defined DOE need
- The R&D proposed for the next stage will not duplicate existing R&D
- Proposed path is technically sound
- Work is progressing as described in the DP
- Potential advantage(s) over baseline and alternative technologies are defined.

STAGE 3: EXPLORATORY DEVELOPMENT

Exploratory Development is the technology development stage during which one or more alternative technologies, methods, or devices are evaluated for potential application to a specific problem. During exploratory development, applications of the technology are specific; work performed during this phase results in defined application concepts.

Stage 3 Information and Documentation Requirements

Before beginning work in Stage 3, the following documents are needed:

- TDRD, modified if appropriate
- DP, modified as needed
- Test Plan, modified as needed
- Market Analysis Report (as directed by the MWFA)
- Tribal, Stakeholder, and Public Involvement Plan (as directed by the MWFA)
- A formal agreement is in place showing end-user and/or commercial partner commitment to the technology.

The PI will provide a detailed test plan and periodic progress reports as called for in the program execution guidance and agreed to in the TTP. At the end of Stage 3, the PI will report results and will be available for formal and informal program reviews as requested by the MWFA.

Go/No-Go Criteria for Transition to Stage 4

Before transitioning the technology to Stage 4, the following "go/no-go" decision criteria must be met.

- The proposed R&D is not a duplication of existing R&D
- Proposed path for Stage 4 is technically sound
- Technology is or fits into a complete system
- Development path meets EM-30/40 procurement strategy
- Cost/benefit analysis is favorable
- Development schedule meets required end-user date
- Tribal and Stakeholder issues identified
- Regulatory/permitting issues identified
- Resulting technology exhibits ability to meet Environment, Safety, and Health (ES&H) requirements
- End-user and/or commercial partner provides at least 10% funding for Stage 4 development
- A formal agreement is in place showing end-user and/or commercial partner commitment to the technology.

STAGE 4: ADVANCED DEVELOPMENT

Advanced Development is the technology development stage following exploratory development. Advanced Development focuses the technology to a specific application. Work performed during this stage results in technology specifications, more detailed performance requirements, proof of practice, and sufficient detail to provide a basis for cost-benefit analysis. Advanced development is co-funded by EM-50, the end-user, and/or commercial partner.

Stage 4 Information and Documentation Requirements

Before beginning work in Stage 4, the following documents are needed:

- TDRD, modified if appropriate
- DP, modified as needed
- Test Plan, modified as needed
- Market Analysis Report (as directed by the MWFA)
- Tribal, Stakeholder, and Public Involvement Plan (as directed by the MWFA)
- A formal agreement is in place showing commitment to the technology.

At the end of Stage 4, the PI will report results as required in the TTP and will also be available for formal and informal program reviews as requested by the MWFA.

Go/No-Go Criteria for Transition to Stage 5

Before transitioning the technology to the next stage of development, the following "go/no-go" decision criteria must be met:

- The proposed R&D is not a duplication of existing R&D
- Proposed path is technically sound
- Technology is or fits into a complete system
- Development path meets EM-30/40 procurement strategy
- Cost/benefit analysis is favorable
- Development schedule meets required end-user date
- Tribal and Stakeholder issues defined - no barriers identified
- Resulting technology exhibits ability to and/or meets regulatory/permitting requirements
- Resulting technology exhibits ability to and/or meets ES&H requirements
- End-user and/or commercial partner provides at least 35% funding for Stage 5 development
- A formal agreement is in place showing end-user and/or commercial partner commitment to the technology.

STAGE 5: ENGINEERING DEVELOPMENT

Engineering development is the technology development stage following advanced development. During the Engineering Development stage, prototype equipment is built to test design features and performance limits. Either bench-scale or pilot-scale systems may be built and tested during the engineering development stage. Resource Conservation and Recovery Act (RCRA) treatability studies are included within engineering development independent of the physical scale of the equipment used. Work performed during this stage results in a technology (but not necessarily an operating system) which is ready for the end-user. Results from the development and testing should provide performance and cost data to support conceptual design and/or capital funding for full-scale production. Funding for engineering development is shared between EM-50 and an end-user or commercial partner.

Stage 5 Information and Documentation Requirements

Before beginning work in Stage 5, the following documents are needed:

- TDRD, modified if appropriate
- DP, modified as needed
- Test Plan, modified as needed
- Market Analysis Report (as directed by the MWFA)
- Tribal, Stakeholder, and Public Involvement Plan (as directed by the MWFA)
- A formal agreement in place showing commitment to the technology.

At the end of Stage 5, the PI will prepare a final test results report as required in the TTP and will also be available for formal and informal program reviews as requested by the MWFA.

Go/No-Go Criteria for Transition to Stage 6

Before the technology is transitioned to Stage 6, the following "go/no-go" decision criteria are satisfied:

- The technology meets a defined DOE need
- Proposed path is technically sound
- The technology is or fits into a complete system
- Technology development team is ready to provide continuity support
- Development path met EM-30/40 procurement strategy
- Market for the technology is satisfied
- Cost/benefit analysis is favorable
- Development schedule meets required end-user date
- Tribal and stakeholder issues resolved
- Regulatory compliance issues resolved
- The technology meets ES&H requirements
- Formal agreement is in place showing end-user and/or commercial partner commitment to the technology.

STAGE 6: IMPLEMENTATION (Post-MWFA Funding)

Implementation is the post-technology development stage when the end-user or commercial partner utilizes the technology for its intended purpose. During the implementation stage the end-user has a fully functional and operational system. In the EM context, the term means that the technology was used or was selected for use to meet specified user performance measures such as assessment complete, remedial action complete, interim action complete, waste treated for disposal, or decontamination and decommissioning complete. Implementation usually does not occur outside of commercial availability and/or procurement.

During this stage, the technology is being implemented by the end-user/commercial partner. Development, per se, has been completed. Proof of concept, feasibility, and scaleup testing have been completed and data required for operating permits have been obtained. Identified tribal and stakeholder issues have been resolved. The end-user/commercial partner has assumed ownership of the technology through agreements in previous development stages. EM-50 support will be service oriented. EM-50 will provide technical oversight of the technology and assist the end-user/commercial partner in addressing technical issues that may arise during the early phases of implementation. Tribal, stakeholder, and regulatory support will be provided to maintain continuity of the communication process during implementation. It may be appropriate to transition these oversight activities to fall under the auspices of the end- user/commercial partner.

MWFA GLOSSARY

Advanced Development - When used in the context of the MWFA development stages, refers to the technology development stage following exploratory development. Advanced development focuses the technology to a specific application. Work performed during this stage results in product specifications, more detailed performance requirements, proof of practice, and sufficient detail to provide a basis for cost-benefit analysis. Advanced development is co-funded by EM-50 and the end-user.

Analysis - When used to mean a method of verification, analysis is a process used in lieu of or in addition to testing to verify compliance with specifications. The techniques typically include interpretation or interpolation/extrapolation of analytical or empirical data under defined conditions or reasoning to show theoretical compliance with stated requirements.

Applied Research - When used in the context of the MWFA development stages, refers to the stage that is a continuation of basic research, with the distinction that knowledge gained from the basic research stage is applied to problems related to potential customers' needs and practical application of this knowledge is identified. Applied research is fully EM-50 funded.

Basic Research - When used in the context of the MWFA development stages, refers to the technology development stage during which fundamental research is undertaken to build core scientific or engineering knowledge; no specific need, end-user, or application of this knowledge is necessarily identified at this stage. Basic research is not typically funded by the MWFA.

Bench Scale - The term implies "bench-scale testing" using the definition of "bench-scale testing" from McGraw-Hill Dictionary of Scientific and Technical Terms - testing of materials, methods, or chemical processes on a small scale, such as a laboratory worktable (see also "exploratory development").

Commercial Partner - A private sector participant who shares the cost and risk associated with the development of a technology.

Commercialization - The process by which technologies that are conceived within the DOE laboratory system are transferred to the private sector for commercial or DOE applications.

Components - The lowest level of items of concern. Unit operations are a functional assembly of components.

Customer - An individual or organization who provides the funding for a set of activities or projects with an expected outcome or product.

Deficiency - See Technology Deficiency.

Demonstration - Demonstration normally has the dictionary definition: 1. The act of making evident or proving. 2. Conclusive evidence; proof. 3. an illustration or explanation as of a theory or product, by exemplification or practical application. When used to mean a method of verification, demonstration is an exhibition of the operability or supportability of an item under intended service-use conditions. These verifications are usually non-repetitive and are oriented almost exclusively toward acquisition of qualitative data. Demonstrations may be accomplished by computer simulation.

End-user - Organizations responsible for treatment of mixed wastes (see also "treatment"). To the extent that

the waste generator is responsible for treatment, storage, and disposal (TSD), the generator may also be an end-user. Most end-users belong to DOE organizations EM-30, EM-40, and EM-60. Potential end-users include companies or industrial organizations who propose to establish mixed waste TSD facilities.

Engineering Development - When used in the context of the MWFA development stages, refers to the technology development stage following advanced development. During engineering development, prototype equipment is built to test design features and performance limits. Either bench-scale or pilot-scale systems may be built and tested during the engineering development stage. RCRA treatability studies are included within engineering development independent of the physical scale of the equipment used. Work performed during this stage results in a technology (but not necessarily an operating system) that is ready for an end-user. Results from the development and testing should provide performance and cost data to support conceptual design and/or capital funding for a full-scale production system. Funding for engineering development is shared between EM-50 and an end-user.

Exploratory Development - When used in the context of the MWFA development stages, refers to the technology development stage during which one or more alternative technologies are evaluated for potential application to a specific problem. During exploratory development, applications of the technology are specific and work performed during this phase results in technology application concepts. Exploratory development is fully funded by EM-50.

Facility - Facility means one of the following: an operation, set of buildings, land, and/or organization dedicated to the treatment of mixed waste (see also “treatment”). Such an operation may be an existing, on-site DOE, or off-site non-DOE operation. It may also include any similar proposed DOE facility that has progressed at least to the initiation of conceptual design. A facility may consist of one or more treatment systems.

Implementation - When used in the context of the MWFA development stages, refers to the post technology development stage when the end-user utilizes the technology for its intended purpose. During the implementation stage the end-user has a fully functional and operational system. (Generally the word implementation will be used with its ordinary English language definition.)

Mixed Waste - Wastes that are both radioactive in accordance with DOE Order 5820.2A and hazardous in accordance with 40 Code of Federal Regulations Part 261. In the MWFA, the term mixed waste refers only to mixed low-level radioactive and mixed transuranic wastes. Mixed high-level wastes are specifically excluded from the scope of the program.

Gates - Decision points in research and development stages as research progresses from basic research to implementation.

Partner - (See "commercial partner")

Pilot-Plant or Pilot-Scale - A small version of a planned industrial plant, built to gain experience in operating the final plant. This definition is obtained directly from the McGraw-Hill Dictionary of Scientific and Technical Terms. Note that the term "small" is not defined and is therefore negotiable; however it is generally accepted that the pilot plant will perform all or most of the key functions of the final facility.

Principal Investigator - A senior member of a development or demonstration team who is responsible for the technical progress and direction of a task being conducted by the team for the MWFA. Generally referred to as the PI.

Prototype - A model suitable for use in complete evaluation of form, design, and performance (from the

McGraw-Hill Dictionary of Scientific and Technical Terms.) In this definition, the term "complete evaluation" refers to the applicable Technology Development Requirements document. Consequently, the term prototype can refer to equipment, processes, or systems of any size, complexity, or stage of development.

Stakeholders - All those who have an interest in the outcome of the Program and includes the public, tribal governments, regulatory agencies, universities, and industries. Members of the DOE and DOE contractors who have a direct and immediate interest or involvement in the MWFA are not considered stakeholders.

System - A group of interacting, interrelated, or interdependent elements forming a complex whole. A system is a functionally related group of elements. (The group may have only a single element. The size of a system is solely dependent on the perspective of the one who defines the system.) A system must have a function and produce a product.

Systems Engineering - A formalized process that translates customer needs and objectives, in concert with applicable external constraints, into system functions and requirements. These functions and requirements define the desired system and the final product, and, in turn, drive and control the system design. Systems engineering is an iterative process that tracks and manages change, progress, and costs. Changes and choices are tracked and documented; decisions are supported by objective analysis and trade studies. As the project evolves, tests are defined and executed to verify that the requirements have or will be met and that the final system will perform all required functions. The system is subdivided into subsystems small enough to manage and track. The technical design and analysis are integrated into the project management and cost control systems.

Technology Deficiency - A roadblock related to a technical aspect of characterization, treatment, handling, or disposal of mixed wastes that prevents the timely, safe, and/or cost effective characterization, treatment, handling, or disposal of those wastes. The term is generally referred to simply as "deficiency." (Specific deficiencies are identified and defined in the Mixed Waste Focus Area Integrated Technical Baseline Report, DOE/ID-10524.)

Test - When used to mean a method of verification, test is an action by which the operability, supportability, performance capability or other specified qualities of an item are verified when subjected to controlled conditions that are real or simulated. These verifications may require use of special test equipment and instrumentation to obtain quantitative data for analysis as well as qualitative data derived from displays and indicators inherent in the item(s) for monitor and control.

Test Plan - A document that describes the technology test objectives and how the test will be designed and conducted to meet those objectives. The test plan describes: test design, sequence of activities, sampling plans, and analytical methods; data collection, reduction, validation and verification, and quality assurance; equipment, instruments, supplies, utilities and facilities; and health and safety aspects of the proposed test.

Treatability Study - The 40 CFR 260.10 definition of treatability study is used without change or exception. A treatability study is a study in which a hazardous waste is subjected to a treatment process to determine: (1) Whether the waste is amenable to the treatment process, (2) what pretreatment (if any) is required, (3) the optimal process conditions needed to achieve the desired treatment, (4) the efficiency of a treatment process for a specific waste or wastes, and (5) the characteristics and volumes of residuals from a particular treatment process. Also included in this definition for the purpose of the Section 261.4(e) and (f) exemptions are liner compatibility, corrosion, and other material compatibility studies and toxicological and health effects studies. A "treatability study" is not a means to commercially treat or dispose of hazardous waste.

Treatment - Any action on a waste that results in a man-induced change-of-state in the waste. Treatment includes any action from the point of generation to disposal of the waste, and therefore includes: characterization, storage, processing, transportation, and disposal.

Treatment System - A logical assemblage of unit operations organized to operate on a waste stream and produce a waste form that meets disposal criteria. In the parlance of the MWFA Technical Baseline, a treatment system may consist of one or more treatment trains as applied to a specific facility. Beyond the technical baseline, the distinction between treatment train and treatment system is blurred. A treatment system must have a target waste stream and a potential programmatic owner (see also "treatment train").

Treatment Train - A process flow diagram for a specific waste stream. It contains more detail than a process flow diagram and will begin to identify specific unit operations for most of the process steps. A treatment train depicts a generic treatment (starting from an existing waste stream through disposal) and will generally have no direct association with a specific system (see also "treatment system").

Unit Operation - The definition of unit operation is identical with that in the McGraw-Hill Dictionary of Scientific and Technical Terms. "The basic physical operations of chemical engineering in a chemical process plant, that is, distillation, fluid transport, heat and mass transfer, evaporation, extraction, drying, crystallization, filtration, mixing, size separation, crushing and grinding, and conveying," or equivalent waste management processes.

Waste Type(s) - This term is used to refer to treatability groups (of wastes) based on definitions in the DOE Waste Treatability Guidance, DOE/LLW-217, generated as part of the Federal Facility Compliance Act process. The DOE/LLW-217 categories have been grouped into the following five waste types used by the MWFA: waste water, combustible organics, debris/solids, homogeneous, solids/soils, and unique.